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Differing Professional Opinion Summary – Erosion

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Overview

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- DPO Process
- Overview of the Waste Treatment and Immobilization Plant (WTP) Pretreatment (PT) Facility
- Panel Membership
- DPO Issues
- Panel's Review, Conclusions, and Recommendations
- Path Forward

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What is the DPO process?

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- The purpose of the DPO process is to bring management attention to technical concerns.
- A DPO is a technical issue that:
  - Differs from previous management decisions, stated positions, established policies, or practices;
  - Has not been adequately considered, in the opinion of the employee;
  - Has the potential for a significant negative impact on environment, safety, and health (ES&H).
- Applies to DOE Federal employees and DOE contractor and subcontractor employees.
- DOE O 442.2, *Differing Professional Opinions for Technical Issues Involving Environmental, Safety, and Health Technical Concerns*, was issued July 2011.

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When should an employee use the DPO process?

- Use for technical issues which, if not sufficiently addressed, could have a significant impact on ES&H
- Only after trying local processes, such as:
  - Use of review and comment processes
  - Discussing with management
  - Submitting to local DPO, employee concern, or other available processes
- Only if the issue remains unresolved
- Issues not considered:
  - Personnel issues
  - Performance issues
  - Contract issues
  - Collective bargaining (union) issues
  - Fraud, waste, and abuse issues
  - Issues for which confidentiality is requested

How to submit a DPO

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- Mail or email to a DPO Manager or
- Submit online at http://www.hss.doe.gov/nuclearsafety/qa/dpo.html

Assigned DPO Managers		
For National Nuclear Security Administration (NNSA) facilities	An NNSA facility	Don Nichols
For DOE Office of Science (SC) facilities	A SC hazard category 1, 2, or 3 nuclear facility[1]	Carol Sohn
	A SC facility other than a hazard category 1, 2, or 3 nuclear facility	Kelli Markham
For DOE facilities under the Office of the Under Secretary	A nuclear facility	Ray Furstenau
	A facility other than a nuclear facility	William Eckroade
For DOE facilities under the purview of the Under Secretary for Nuclear Security (other than NNSA facilities)	A nuclear facility other than an NNSA facility	Richard Lagdon
	A non-nuclear facility other than an NNSA facility	William Eckroade
For DOE facilities other than under the purview of SC, the Under Secretary for Nuclear Security, or Office of the Under Secretary of Energy	All facilities	William Eckroade

[1] See Title 10, Code of Federal Regulations, Part 830, *Nuclear safety management*, for definitions of nuclear facility and hazard category 1, 2, and 3 nuclear facilities.

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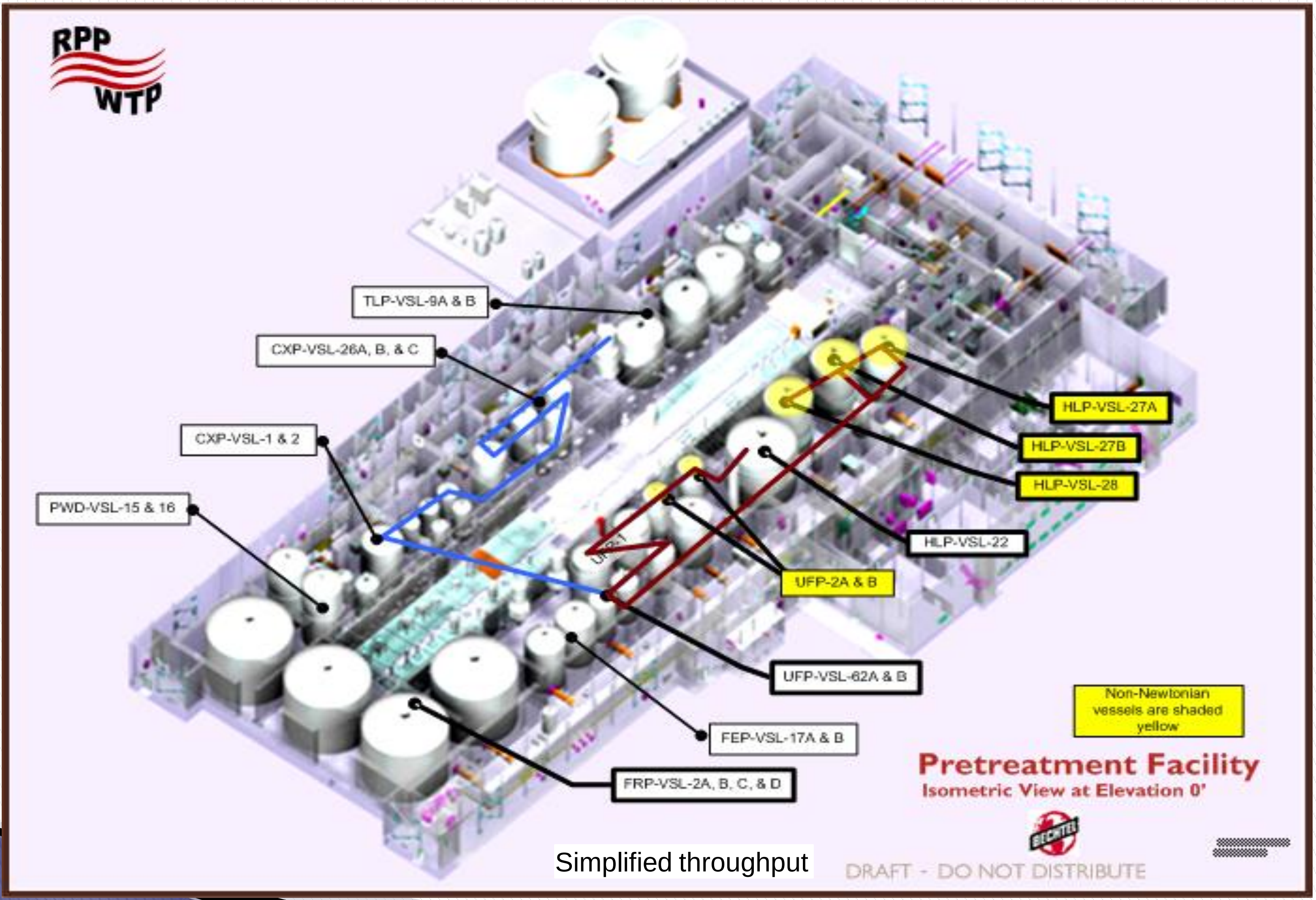
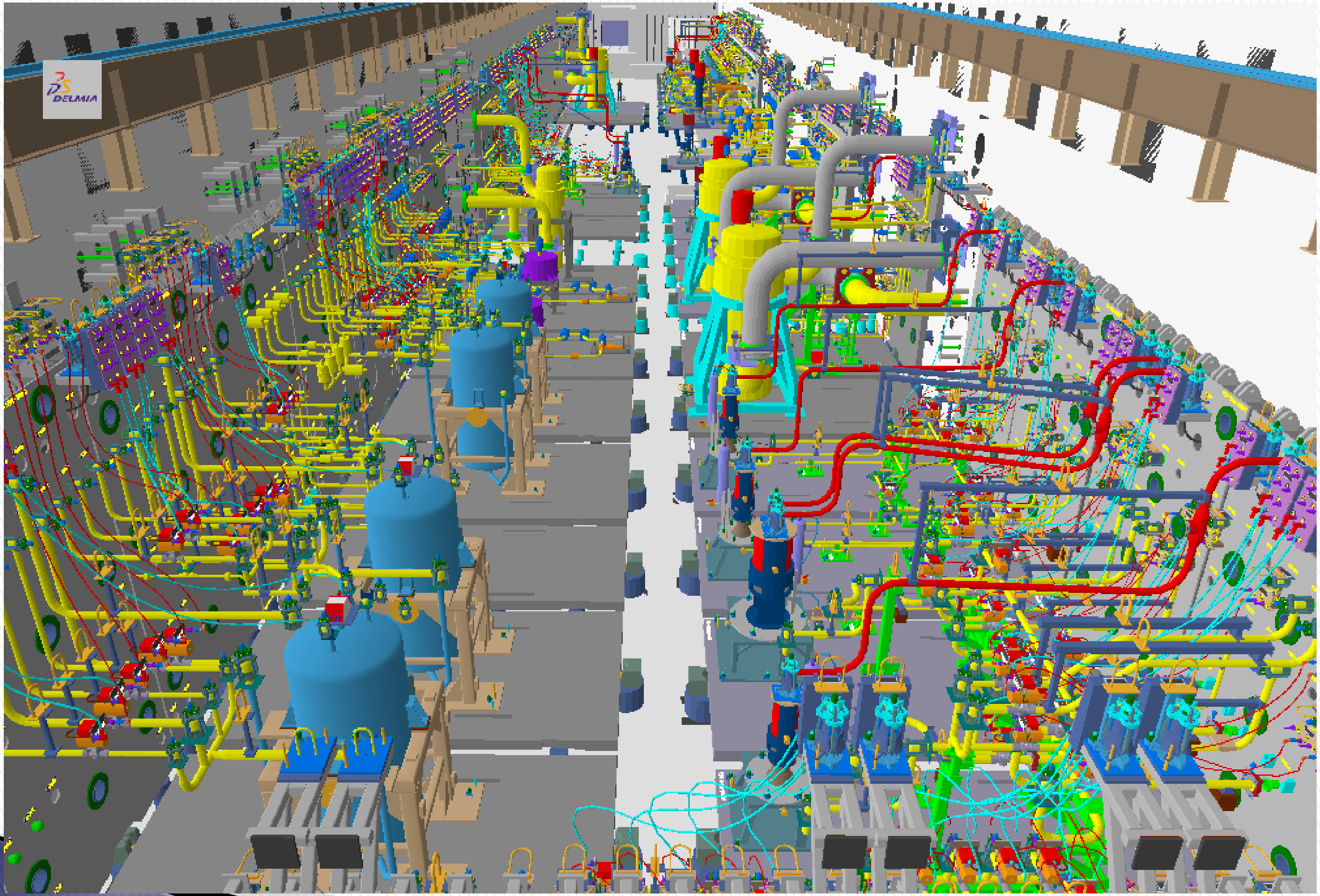
Pretreatment Facility

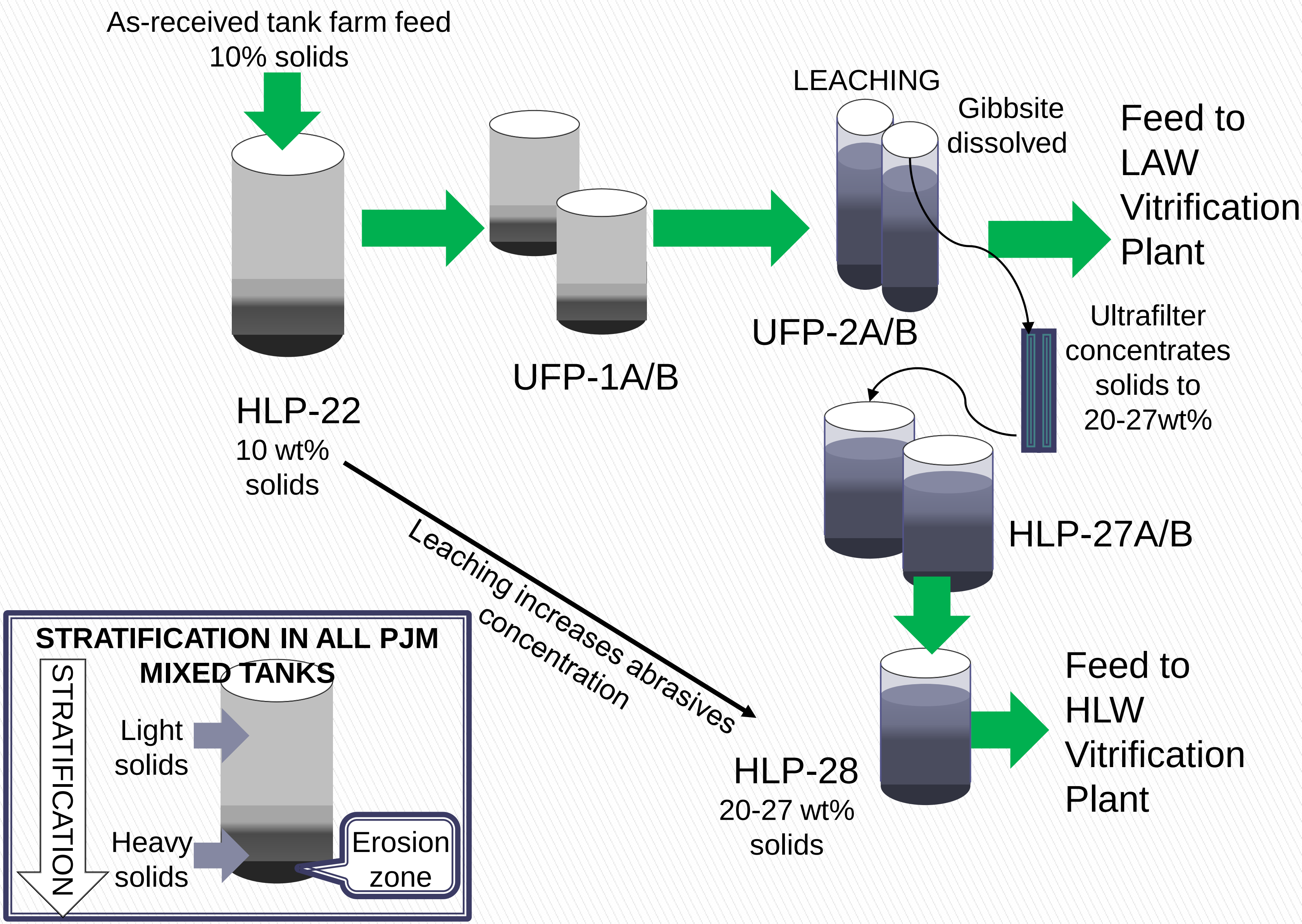


Simplified throughput

PT: Hot cell looking east



Process steps in the PT Facility



WTP Project Approach

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- Design objective was to process all the waste in the tank farms
  - Uncertainties worked out during startup
  - Established in the consent decree
  - Waste characterization is ongoing process
- Black cell design established that doesn't permit access for life of the plant
- Present design may process some large percentage of wastes

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DPO Panel

- Dr. Robert Nelson, Chair
- Professor Ron Ballinger, Massachusetts Institute of Technology
- Professor Jerry Frankel, Ohio State University

DPO Part 1: Faulty non-Newtonian vessel design

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- **Contractor design model invalid for application to non-Newtonian vessel (NNV) performance:** The Low-Order Accumulation Model (LOAM) Computational Fluid Model (CFD) being used to model the NNV, and upon which conclusions about the efficacy of the NNV design were being based, was flawed for those purposes.
- **Design basis for fabrication of vessels is incomplete:** The engineering documents that supported the design were incomplete and not in accordance with BNI procedures.
- **Testing basis is incomplete:** The testing done to support the design of the NNV was inadequate.
- **The fabrication of vessels is premature until fundamental design and performance issues are addressed:** Based on the above three issues, the DPO submitter contended that it was inappropriate to weld the NNV heads on until these issues are resolved.

DPO Part 1: Results

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- Contractor design model invalid for application to NNV performance:
  - **ORP Panel Agreed:** LOAM no longer being used by project for design
- Design basis for fabrication of vessels is incomplete:
  - **ORP Panel Agreed:** Uncertainties to be evaluated during large-scale integrated testing
- Testing basis is incomplete:
  - **ORP Panel Agreed:** Project addressing issue through acceptance of surveillance and ongoing NNV testing
- The fabrication of vessels is premature until fundamental design and performance issues are addressed:
  - **ORP DPO Panel Disagreed:** Management decision was appropriate. QA processes permit this practice; however, defective components should be tracked.

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DPO Part 2: Black cells not viable due to erosion in faulty WTP non-Newtonian vessels and piping design

- Erosion of the black cell vessels and piping that manage high quantities of solids could lead to the loss of vessel contents and result in spray releases. These high solids-containing vessels include five non-Newtonian vessels (HLP-28, HLP-27A/B, and UFP2A/B) and five Newtonian vessels (HLP-22, UFP-1A/B, and FEP-17A/B).
- High-velocity jets and angled perimeter nozzles will erode vessel components, adversely affect flow, and potentially result in vessel penetration that will lead to flooding of the black cells and cause spray leaks.
- Previous erosion testing (M2 wear testing) was not bounding for the five non-Newtonian vessels; the simulant used was not representative of the materials received in the non-Newtonian vessels, and the actual solids to be managed in the non-Newtonian vessels will be considerably more abrasive than the solids used for M2 testing.

DPO Panel Charter

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In addition to reviewing the merits of the DPO, the Panel was tasked with answering the following questions:

- *What is BNI's strategy for addressing erosion and corrosion?*
- *Is the technical basis for the erosion-corrosion strategy correct?*
- *How does the strategy compare with industry?*
- *Based on the design, is the plant expected to meet its 40-year design life?*

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Black Cell Piping Arrangement

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General wear relationship for erosion wear around the circumference of a horizontal pipeline

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$$E = A \times (V)^n \times (d)^p \times (C)^q$$

- A= constant
- E= wear rate (mm/yr)
- V= slurry velocity (m/s)
- d = mean particle diameter (mm)
- C = slurry solids content as a weight fraction
- n, p, q = fitted parameters

Reference:
Gupta, R., S.N. Singh, V. Sehadri, *Prediction of Uneven Wear in a Slurry Pipeline on the Basis of Measurements in a Pot Tester,* Wear, 184 (1995).

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DPO Panel observations

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- BNI took a standard approach to the issue of erosion; however:
  - The resulting data were extensively scattered, some outside the literature range
  - The approach did not account for slurry changes throughout the process
  - The potential interaction between erosion and corrosion was not adequately addressed.
- Although a high pH will result in very low general corrosion rates, they will be influenced if lower pH or oxidizing conditions are present
- The conditions of the flow stream have not been used to generate a tank-specific rate relationship.
- In spite of best efforts to develop a rate law that bounds the system, there is likely to be unknown and large uncertainty in the predicted rates.

Panel observations

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- BNI's potential approach to bounding erosion rates includes:
  - Preprocessing waste to ensure that the particle size distribution is within design limits
  - Calibrating the expected erosion rates using surrogate materials that bound concentration, hardness, and other properties
  - Characterizing samples of actual tank waste
  - Determining the expected erosion rate based on a comparison of actual tank waste and surrogate
- The problem remains that there are uncertainties in all of the parameters used in the determination of correlation that describes the erosion rate.
- The project's approach to designing against erosion and erosion-corrosion represents a non-probabilistic approach to the problem. However, the dependence of the erosion rates on the key variables contains uncertainties that are not likely to be accounted for.

Panel observations – corrosion

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- A corrosion evaluation document has been generated for each component in the plant that describes design parameters and operating conditions.
  - A clear rationale for selected material is not always provided.
  - Selections made in the corrosion evaluations are based on the minimum required properties rather than conservative approaches.

- A classification scheme was developed that grades the harshness of the materials environments and provides an associated summary of the technical issues. The Panel was unable to do a thorough review of this analysis, but recommends that an external panel be tasked to do so.

Panel observations – corrosion

The approach to materials selection involving assessment of the environment, comparison with published data, and selected testing, comprises a standard practice for a typical industrial application like a chemical plant. However, because of the requirements of a black cell operation and the consequences of a premature failure of the WTP, a more rigorous and conservative approach is called for. It is reassuring to find no evidence of localized corrosion or stress corrosion cracking in environments that are meant to represent the operating conditions; however, such tests provide no information about the margin of safety or the safe operating window.

DPO Panel recommendations

A. The Project should perform a quantitative analysis of failure probability.

B. Based on the results of the failure probability analysis, the Project should determine the critical gaps in understanding and perform testing and analysis to close the gaps.

C. In assessing the probability of failure, the Project should use conservative measures as a means of reducing uncertainty.

DPO Panel Recommendations

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D. If it is determined that there is a need to reduce the probability of failure or the uncertainty of the design, the Project could consider changes to the materials of construction or to the process.

E. The project needs to develop a comprehensive approach to online or spot monitoring of the system condition. This plan should adequately assess expected critical areas.

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Benefits of Risk Analysis

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- The analysis provides for a statistically rigorous estimate of the probability of various events and thus meaningful estimates of the process reliability and service life. It is critical to have this type of analysis for components in the black cells where the consequences of failure would be extremely costly.
- The analysis provides for a rigorous estimate of the amount of uncertainty in the estimated failure probability.
- The analysis requires the real sources of uncertainty in the system operation to be identified and quantified. The level of accuracy in quantification is highest if an extensive database exists and is lowest for cases where engineering judgment is all that is available and where little relevant data exist.
- The analysis allows the determination of the sources of uncertainty in the overall analysis, thus providing information as to where to focus analytical /experimental efforts or system-specific condition monitoring.
- Properly done, the analysis provides a tool for evaluating the impact of processing changes on duty cycle for a system.
- The analysis may be used to provide a rationale for extending life beyond the 40-year design life if required.

Fitness-for-Service Description

1. Definition of the overall system
2. Initial evaluation of the potential failure modes
3. Database development
4. Component degradation model development
5. Remaining life model development
6. Uncertainty development
7. Probability of failure determination
8. Gap analysis

Path Forward

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- Transmit DPO Report to the project
- Determine approach to applying Fitness-for-Service methodology
- Execute recommendations
- Conduct peer review of final results

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